Asymmetric response of precipitation to ENSO in CMIP6 models

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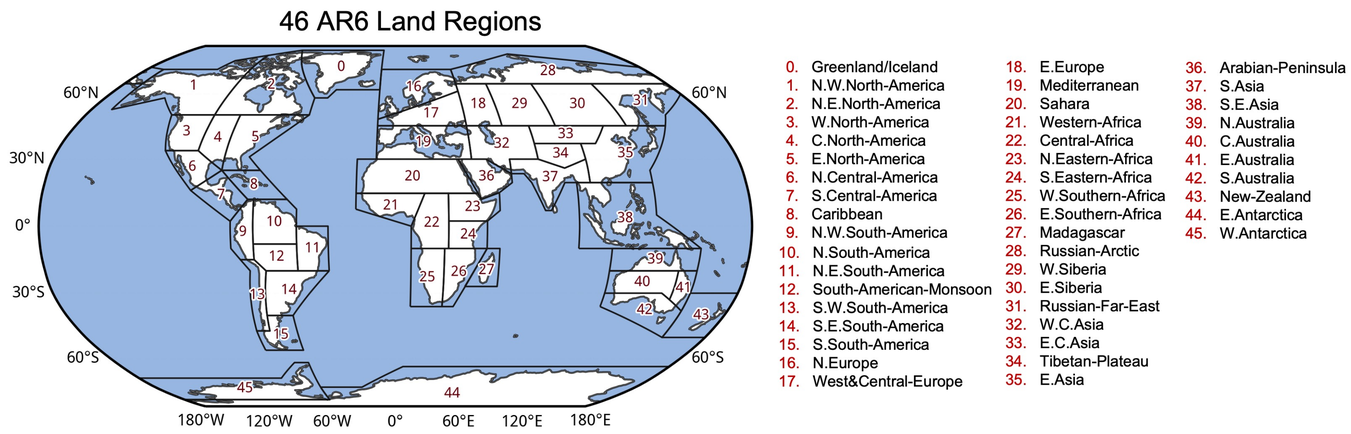
ENSO-precipitation asymmetry is a significant component of ENSO teleconnections in many regions. This study analyses this component in 46 AR6 regions and across 50 CMIP6 models identify seasonal and regional diversity in model performance.

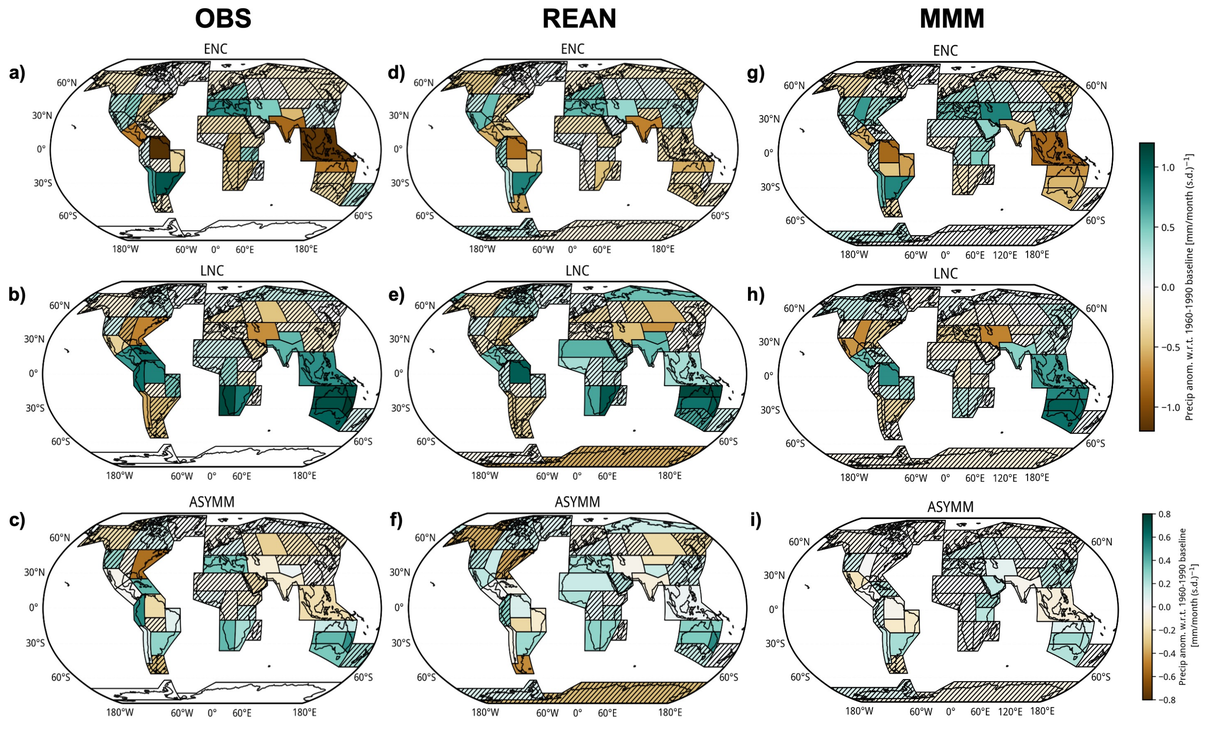


Background and Motivation

El Niño Southern Oscillation (ENSO) is a prominent climate phenomenon affecting the variability of regional precipitation. The precipitation response, during El Niño and La Niña phases, compared to neutral phase, are not mirror images of one another. In Australia, for instance, it gets much wetter during La-Nina, compared to the neutral phase, as it gets drier during El Niño, and this asymmetry plays an important role in drought breaks. There are few studies that analyse the seasonal differences in asymmetric response, while others do a global assessment of the regional differences in the asymmetric response. But there are no studies that analyse the ability of the CMIP6 models to simulate the seasonal and regional differences in the asymmetric response.

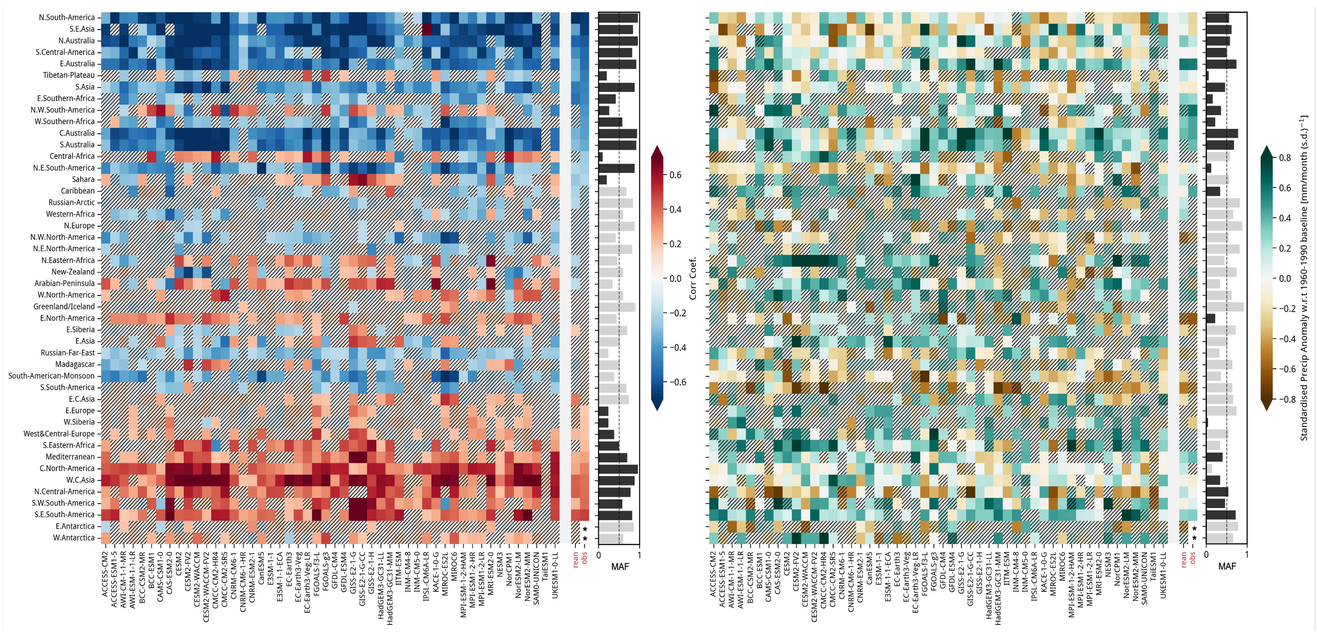
How well do models simulate annual asymmetry?

The figure below shows the regional diversity ENC, LNC and ASYMM components during the ANN. Simulated asymmetric response in the MMM is lower in magnitude but captures the spatial variability well especially particularly in Australia and Maritime Continent but not over Africa and Asia.



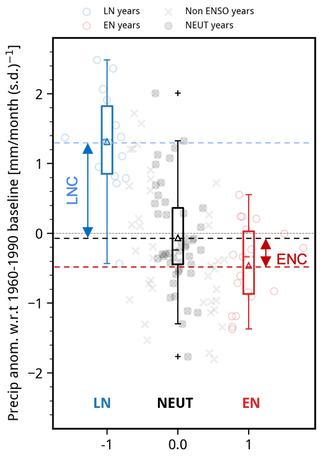
Model Agreement for annual teleconnections

Model Agreement fraction (MAF) represents the fraction of models (out of 50) that agree with the direction and stat. sign. of CORR (left) / ASYMM (right) in OBS [REAN for West and East Antarctica]. The black bars are regions where CORR is statistically significant. Reduced MAF for ASYMM is seen compared to CORR during ANN period.



Data and Methods

Observation data (OBS) : GPCP monthly precipitation data; HadISST data
Reanalysis (REAN) : NOAA 20th Century Reanalysis precipitation.
CMIP6 : 50 models including ACCESS-CM2 and ACCESS-ESM1.5



$$LNC = \overline{LN} - \overline{NEUT}$$

$$ENC = \overline{EN} - \overline{NEUT}$$

$$ASYMM = (ENC + LNC) \cdot 0.5$$

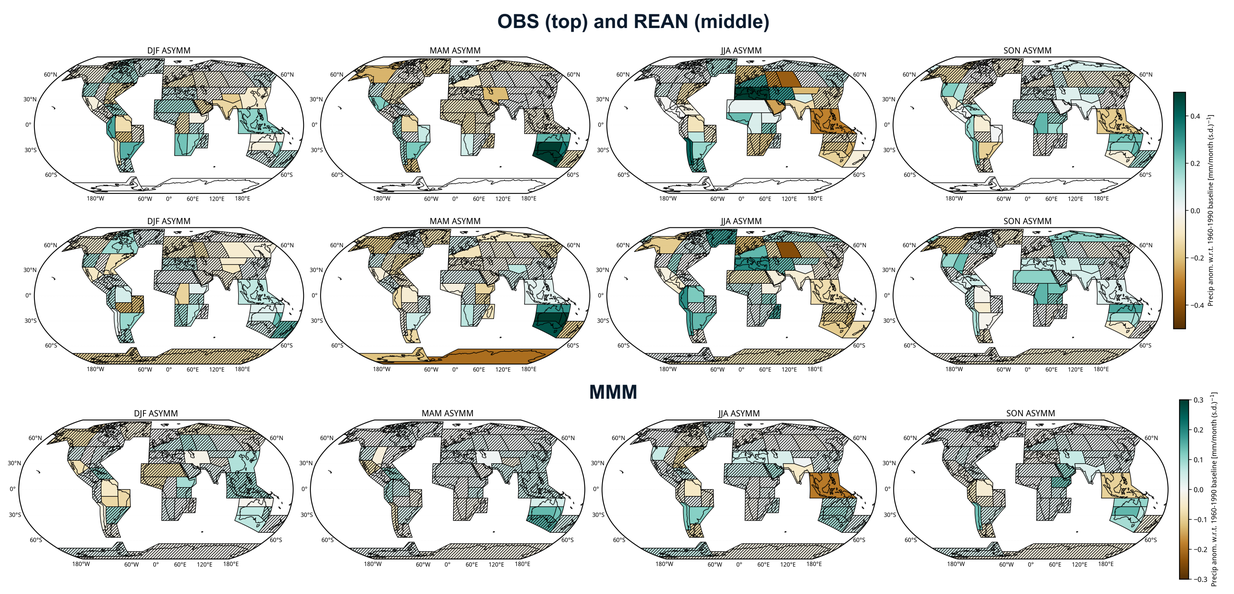
$$If \quad p_{ENC}^{mwu} > 0.05$$

$$and \quad p_{LNC}^{mwu} > 0.05$$

$$\Rightarrow \quad ASYMM \text{ is stat. insig.}$$

$$else \quad ASYMM \text{ is stat. sig.}$$

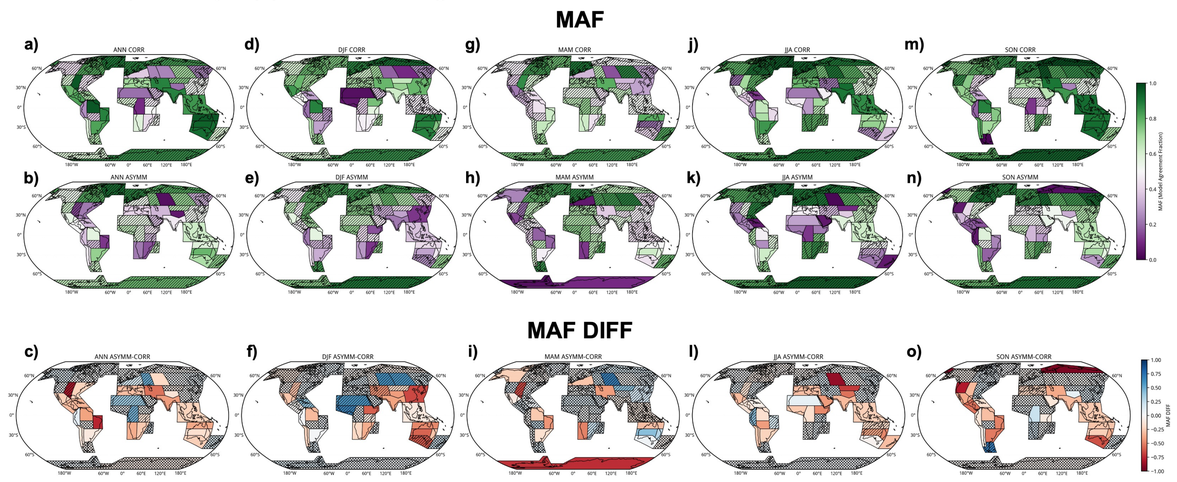
How well do models simulate seasonal asymmetry?



Reduced model agreement for seasonal asymmetry

MAF for CORR and ASYMM are shown in the top and middle rows of the figure below with the difference between them shown in third row.

- MAF CORR is higher than MAF ASYMM during the ANN period and in all seasons in all regions where both CORR and ASYMM component are found to be statistically significant.
- This is especially apparent during the ENSO active seasons of SON and DJF.



Conclusions

- Regional and seasonal diversity in asymmetric response is apparent.
- Model performance varies with seasons.
- Model agreement is higher (lower) for capturing teleconnections (asymmetry)